



TRIAL SUMMARY

<p>The objective of this trial was to assess the fuel efficiency and GHG outcomes of two refrigerated vehicles under two scenarios:</p> <ol style="list-style-type: none"> <li>1. when plugged into a three-phase power source;</li> <li>2. when using diesel generated power.</li> </ol> <p>Both vehicles operated in a metropolitan distribution application in Brisbane, Queensland.</p>	<p><b>GHG benefit (kg CO<sub>2</sub>-e /h)</b></p> <p><b>49%↑ (saving 6.47 kg/h)*</b></p>	<p><b>Economic benefit (\$/h)</b></p> <p><b>87%↑</b></p>
<p>↑ performance better than conventional vehicle                  ↓ performance worse than conventional vehicle</p> <p>* GHG and cost savings are for every hour of refrigeration motor operation when plugged into three-phase power. This represented 15–30% of time the refrigeration unit was active or 3–7% of total hours of vehicle operation.</p>		

The *Green Truck Partnership* is designed to be a forum for the objective evaluation of the merits of clean vehicle technologies and fuels by heavy vehicle operators. This report discusses the results of a trial of electric standby refrigeration technologies for use in refrigerated transport and storage supply chains conducted under the program in 2012.

**1 ELECTRIC STANDBY TECHNOLOGIES**

The design and application of a refrigeration unit can have a significant effect on the overall fuel consumption of a refrigerated truck. Small truck units are sometimes powered directly from the vehicle engine, while large truck and refrigerated trailer units can be powered by a stand-alone independent diesel generator with electric stand-by motor.

Electric standby refrigeration uses an external electricity source and electric motor to maintain the internal temperature of the trailer during extended stops or to pre-cool the trailer prior to loading – thereby reducing the cooling energy required on vehicle start-up.

This technology is remote from the vehicle and typically installed at the loading dock of a refrigerated distribution centre. In this way, the trailer can be cooled when standing at the loading dock using electricity sourced from the national grid, thereby eliminating the need to either operate the truck (in the case of small trucks) or the vehicle mounted refrigeration unit (in the case of larger refrigerated trucks).

The sourcing of electricity to power the refrigeration unit potentially eliminates tailpipe emissions, reduces noise and reduces maintenance costs associated with running a diesel engine.

However, the practical realisation of these benefits depends on a number of factors, including the cost of electricity, the time of power use (given varying electricity tariff rates at many facilities), and whether three-phase power is available at the dock.

While electric standby refrigeration technology potentially eliminates GHG emissions emitted by the vehicle, there is a need to consider the consequence of upstream GHG emissions

associated with the production of the electricity utilised by the refrigeration units. Specifically, the GHG emissions produced as a result of electricity generation will vary according to the feedstock used (e.g. brown coal, black coal, hydro, solar) and these emissions must be considered in the overall GHG assessment of the technology.

## 2 TRIAL OBJECTIVE

The purpose of this trial was to assess the real world economic and environmental performance of electric standby technology for refrigerated trailers, relative to conventional diesel refrigeration technology.

## 3 METHODOLOGY

### DATA COLLECTION

The trial involved an in-field assessment of two vehicles running metropolitan distribution routes in Brisbane, Queensland, and operating simultaneously over a six-week period between May 2012 and June 2012. The vehicles were refrigerated in both diesel only and electric standby with a view to collecting field data for comparison.

During the trial period, data loggers were used to collect data from the refrigerated trailers to ensure validity of the fuel comparison. The data collected by the loggers during the course of the trial included:

- **TEMPERATURE:** return air temperature (°C).
- **TEMPERATURE SET POINT:** specified trailer temperature (°C).
- **ENERGY TYPE:** type of energy used (diesel or electricity).
- **MOTOR FUNCTION:** recorded status of motor (cool, high cool, heat, defrost).

During the trial period, fleet fuel records were used to capture fuel consumption data (as this

could not be captured from the data loggers on the trailers). The fuel data collected included:

- **FUEL CONSUMPTION:** total fuel (litres) supplied to the self-powered SLX 400 refrigeration unit in the trial period.

### DATA ANALYSIS

Key descriptors considered in this analysis included trailer temperature, refrigerator motor function, energy hours and fuel consumption.

This data was used to assess the average performance of the trailers throughout the trial, and identify any periods where the trailers were working harder in cool or heat mode to maintain the set point temperature.

Once the data validation process was completed, the fuel efficiency performance of the trailers was compared in electric standby mode and diesel mode. The results of this comparison are discussed in Section 4.

In order to ensure the validity of the fuel consumption comparison, the changes in ambient air temperature and refrigerator motor function data were collected during the course of the trial. Given that these vehicles were performing similar delivery tasks, these two descriptors were considered sufficient to ensure validity of the technology comparison.

The average ambient air temperatures of trailer 1 was 3.87°C and was 3.91°C for trailer 2, suggesting that the operating of the two trailers was largely identical (i.e. less than 1% variance in ambient internal temperatures).

Figure 3 shows the recorded temperature readings for each trailer over the trial period.

The motor function is essentially a measure of how the motor is working and is measured by the amount of time spent undertaking a certain

function to maintain the temperature set point (i.e. cooling, heating, defrost, null).

For the product carried in this trial the temperature set point was always 2°C. This parameter can be influenced by a number of factors including the type and volume of product being carried, the frequency of door opening events, time of operation and ambient air temperature.

The motor function data indicated that 18–20% of hours were at the ‘cool’ setting and 3% were at the ‘heat’ setting’ (Figure 1). Once again, this indicates that the motor function profiles of each trailer were very similar during the trial period (Figure 2).

#### 4 RESULTS

A summary of the field data collected for the two trailers comprising the trial is provided in Table 1 below.

Table 1 Trailer operating characteristics		
Operation	Trailer 1	Trailer 2
Diesel motor hours	77	97
Electric motor hours	28	16
Total motor hours	105	113
Total hours of operation	436	456
Diesel consumption (L)	371.50	475.70
Diesel consumption (L/h)	4.82	4.90
Average ambient temperature (°C)	3.91	3.87
Diesel savings (L)	135.09	78.47
Electricity consumption (kWh)	215.60	123.20

In addition to the field data collected, there was a need to apply a series of GHG intensity and electricity cost assumptions for the purposes of the analysis. This data is summarised below.

#### GHG emissions

- 0.86 kg CO<sub>2</sub>-e/kWh
- 2.694 kg CO<sub>2</sub>-e/L of diesel

#### Energy cost

- \$1.40/L of diesel
- \$0.11/kWh of electricity

#### Energy consumption

- 4.8–4.9 L of diesel per hour of operation
- 7.7 kWh of electricity per hour of operation.

#### TRAILER 1

During the trial period Trailer 1 spent 26% of its total motor hours using three-phase power compared to diesel.

Comparison of the fuel consumption results for Trailer 1 revealed that the trailer saw an 87% reduction in fuel costs (\$5.9/h) when plugged into electricity versus using diesel (Figure 4). This amounted to a total saving of approximately \$165 across the trial period.

Analysis of the GHG performance (Figure 5) reveals that the GHG emissions generated by Trailer 1 when using electricity were 49% lower than when using diesel. This amounted to a saving of 178 kg CO<sub>2</sub>-e across the trial period or 6.36 kg CO<sub>2</sub>-e/h.

#### TRAILER 2

During the trial period Trailer 2 spent 14% of its total motor hours using three-phase power compared to diesel.

Comparison of the fuel consumption results for Trailer 2 revealed that the trailer saw an 87% reduction in fuel costs (\$6/h) when plugged into electricity versus using diesel (Figure 4). This amounted to a total saving of approximately \$96 across the trial period.

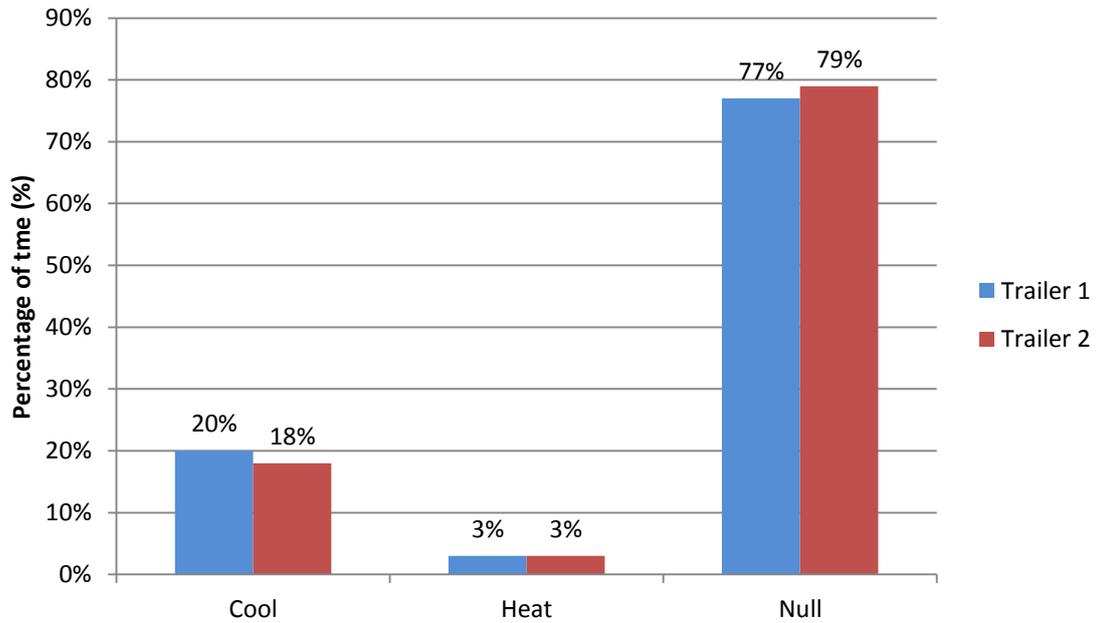
Analysis of the GHG performance (Figure 5) reveals that the GHG emissions generated by Trailer 2 when using electricity were 49% lower than when using diesel. This amounted to a saving of 105 kg CO<sub>2</sub>-e across the trial period or 6.58 kg CO<sub>2</sub>-e/h.

## 5 CONCLUSION

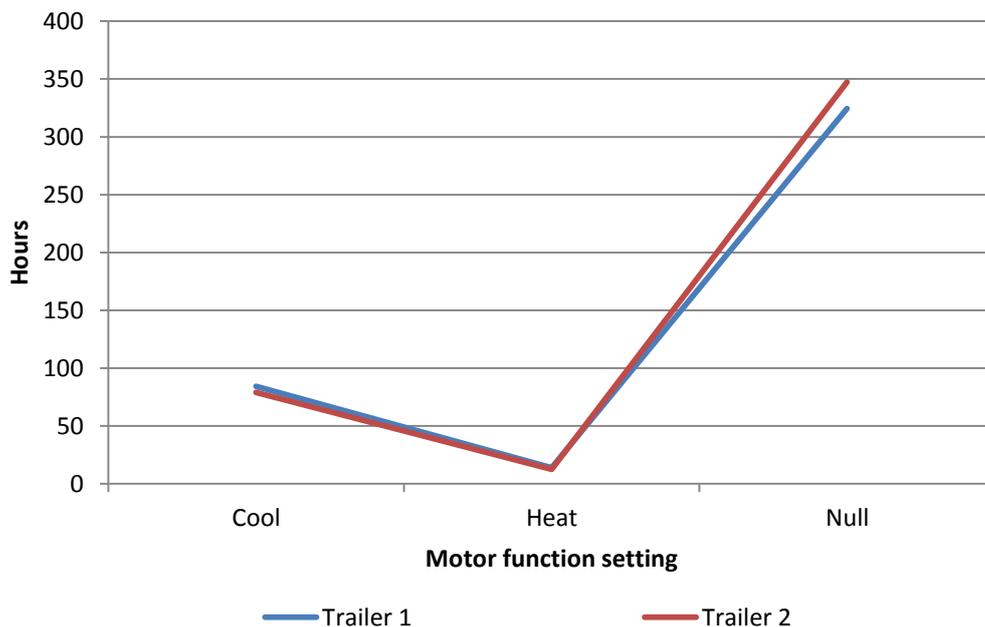
The findings of this trial suggest that using electric standby refrigeration technology for single trailer application in metropolitan areas delivers a fuel cost saving of approximately 87%, relative to conventional diesel powered trailer refrigeration technologies. This fuel saving, however, needs to be considered relative to the additional capital cost of electric stand-by refrigeration technologies, relative to conventional diesel technologies.

The results of the trial demonstrated that the use of electric standby technology in lieu of conventional diesel refrigeration technologies delivers a net GHG emission benefit of 49% (for electricity sourced from Australian average black coal generation).

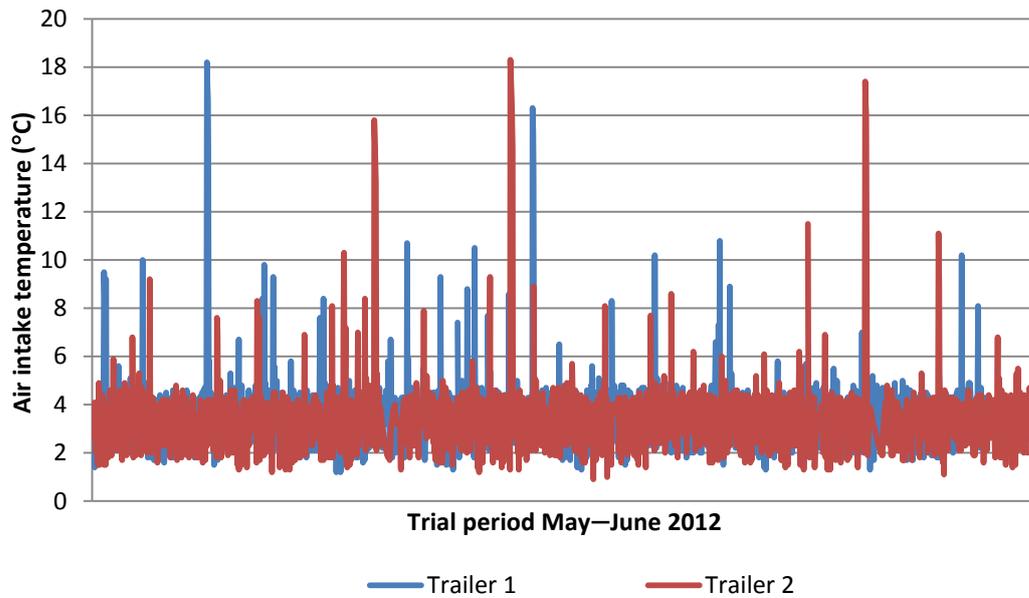
**Figure 1**  
Percentage of time spent at each motor function setting



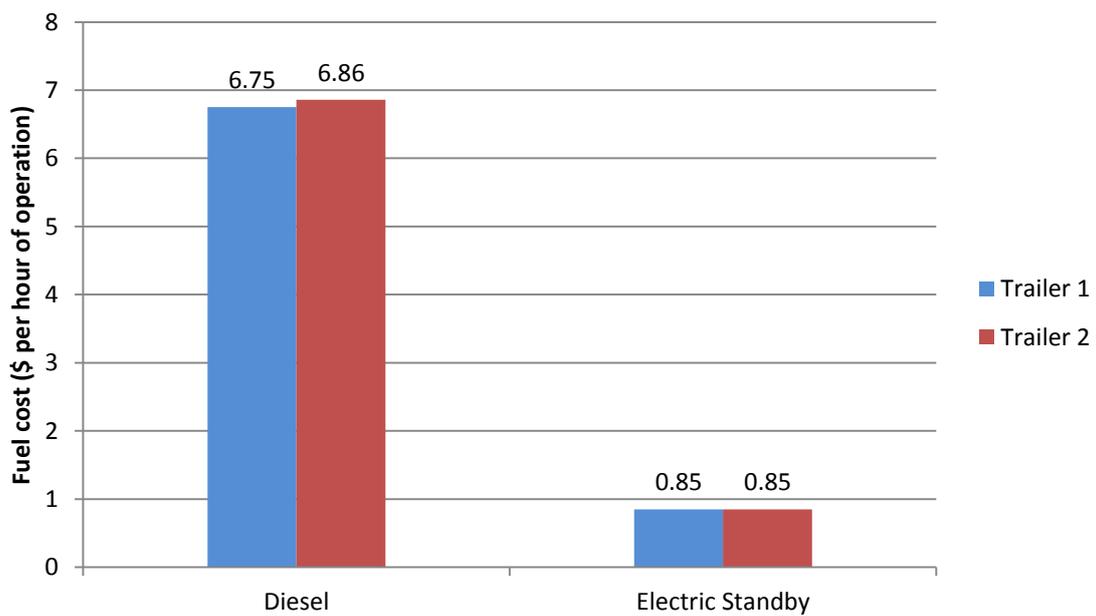
**Figure 2**  
Comparison of refrigerated trailer motor function across trial period



**Figure 3**  
Comparison of refrigerated trailer temperatures across trial period



**Figure 4**  
Comparison of diesel and electric standby fuel costs across trial period



**Figure 5**  
**Comparison of diesel and electric standby**  
**GHG emissions across trial period**

